69

SUPPLEMENT

TO

THE JOURNAL OF THE INDIAN MATHEMATICAL SOCIETY.

Volume XVI.

OFFICE OF THE REGISTRAR OF BOOKS
4 OCT 1926
MADRAS

REPORT

OF

THE FIFTH CONFERENCE

OF

THE INDIAN MATHEMATICAL SOCIETY

HELD AT BANGALORE IN APRIL, 1926.

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MADRAS:
PRINTED BY SRINIVASA VARADACHARI & CO.
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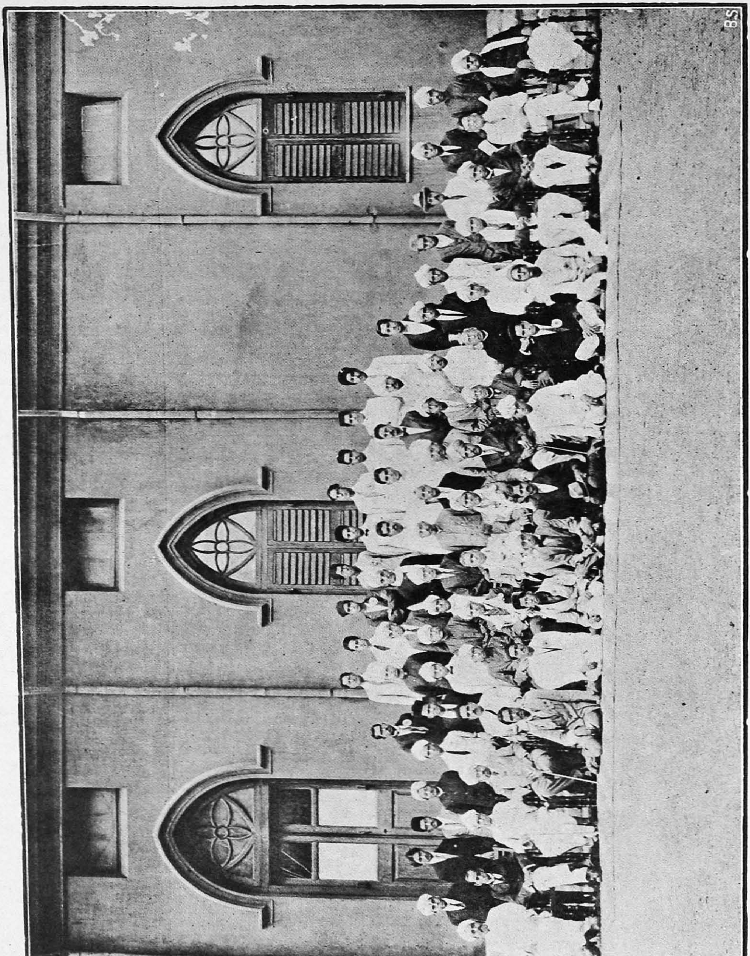

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Report of the Fifth Conference of the Indian Mathematical Society.

(Bangalore, April 1926.)

The Fifth Conference of the Indian Mathematical Society was held in the Central College, Bangalore, on the 2nd, 3rd and 4th April 1926.

The Working Sub-Committee attended to the details of the arrangements. Delegates from different parts of India numbering over 40 attended the Conference and were mostly accommodated in the Central College Hostel. The guests went away well pleased with the reception accorded to them and the arrangements made for their convenience.

The President-Elect arrived on the morning of the 1st April and was received at the City Railway Station by select members of the Reception Committee and was conducted to his quarters.

A set of student volunteers was in attendance throughout and rendered very useful service.

OPENING DAY.

The opening function took place at 12 noon on the 2nd April in the Lecture Hall of the Mathematics Block, where in addition to the members of the Society and delegates, many distinguished gentlemen had gathered in response to the invitation issued by the Reception Committee.

The Proceedings began with a short invocation by Mr. V. Krishnamurthy, B. Sc.

Rajatantrapravina Dr. Brajendranath Seal, M. A., Ph. D., D.Sc., Vice-Chancellor of the Mysore University, read a Message from His Highness the Maharajah of Mysore and then delivered his speech as Chairman of the Reception Committee welcoming the guests and delegates to Bangalore.

Rao Bahadur P. V. Seshu Aiyar next read the Secretary's Report on the working of the Society.

The retiring President, Mr. Balak Ram, M.A., I.C.S., then on behalf of the members presented an Address to Mr. V. Ramaswami Iyer, Founder of the Indian Mathematical Society; and Mr. V. Ramaswami Iyer was then duly installed as the new President of the Society.

The new President then delivered his Presidential Address.

Mr. Balak Ram referred to the distinguished careers of two junior members of the Society at foreign Universities, *viz.*, Dr. R. Vaidyanathaswami who was awarded the D.Sc. of Saint Andrews University, and G. S. Mahajani who won the Smith's Prize at Cambridge, and congratulated them on their achievements.

With a vote of thanks to His Highness the Maharajah of Mysore for his gracious message and to the University of Mysore for their liberal contribution, the function terminated.

* * * *

At 2-30 p.m. there was a business meeting of the Society and at its conclusion, lunch was provided to all the guests. Afterwards, the party visited the laboratories of the Central and the Engineering Colleges, where interesting demonstrations had been arranged.

At 6-30 p.m. Mr. S. V. Ramamurthy, M.A., I.C.S., delivered a public lecture on 'Philosophy, Mathematics and Science' to a large and appreciative audience.

THE SECOND DAY.

On the 3rd April a group photograph of the members and delegates was taken at 8 a.m. and the rest of the morning was devoted to the reading of papers.

In the afternoon, the visitors were taken round to the following places :—

(i) The Indian Institute of Science.
(ii) The Jewell Filters.
(iii) The Sandal Oil Factory.
(iv) The A-Station

The authorities in charge received them very kindly and showed them round. The Working Sub-Committee had made arrangements for lunch at the Jewell Filters and the visits were much enjoyed by the party.

In the evening, the members motored to the Century Club in response to a special invitation by Mr. K. R. Srinivasa Iyengar and others.

THE THIRD AND LAST DAY.

The Conference resumed its sittings on the 4th April at 8 a.m. and the reading of papers was concluded at 11-30 a.m.

In the afternoon, there was a discussion meeting at 3-30 p.m. when Rao Bahadur P. V. Seshu Aiyer introduced the subject of 'Rigour in the Teaching of Mathematics.' A lively discussion followed in which Messrs. G. A. Srinivasan, C. N. Srinivasa Iyengar, K. R. Gunjikar, K. S. Kuppuswami Iyengar, B. S. Madhava Rao and R. Vaidyanathaswamy took part.

The session was brought to a close by the concluding speech of the President in which he thanked all those who had contributed to the success of the Conference.

In the evening at 5-30 p.m., Dr. Seal, Chairman of the Reception Committee, was *At Home* to all the Members and Delegates of the Conference. Many officers of the State, members of the University Council and the Senate and the elite of Bangalore had been invited to meet the guests. Refreshments were served in the garden of the Meteorological Observatory adjoining the Central College. Dr. Seal received the guests individually and the guests enjoyed a very pleasant evening.

EXCURSIONS.

A few members left the station on the 4th April by the night train. Those who stayed on were taken round the City on the morning of the 5th April.

In the afternoon the Government Soap Factory was visited with the kind permission of Mr. S. G. Sastri, M. Sc.

The 6th April was spent in visiting the Kolar Gold Fields. The party left for Mysore the same night and was received by Mr. K. B. Madhava who showed them round Mysore, Seringapatam and Krishnaraja Sagara. Arrangements were also made for a visit to Sivasamudram in the case of a few.

Message from His Highness the Maharajah of Mysore.

Members of the Mathematical Conference:

It gives me great pleasure to extend to you a cordial welcome to my State and to assure you of my deep sympathy in your endeavours to revive the old Indian tradition in a branch of Science, in respect of which India's contributions have been of fundamental importance.

Beginning in a humble guise eighteen years ago as the Indian Mathematical Club, your Society opened both a Central and a Circulating Library and started a Mathematical Journal. In this Journal were published the early memoirs of Ramanujan, the greatest mathematical genius of modern India and a world-mathematician of the highest order. Such was the scope and power of his intellect that, as I gather, his solitary and unaided work achieved the development of mathematical forms and functions from the stage of Bhaskaracharya and Mahavira to that reached by Western Mathematicians in the early nineteenth century. It is a matter for infinite regret that death ended his labours just when the recognition of his powers had brought him opportunities which would have meant far greater achievement. Genius like his may not occur in centuries, but it remains an inspiration as well as an indication of national capacity.

I am convinced that both the corporate efforts of your Society and the individual work of some of its members will find an honoured place in the records of Mathematical explorations. You can do much fine public service both in the extension and the improvement of Mathematical studies within the sphere of your influence. Your unceasing enthusiasm and the very names of your office-bearers, guarantee your success. My best wishes go with you.

Welcome Address

By Dr. Brajendranath Seal, M.A., PH.D., D.Sc.

Chairman of the Reception Committee.

(2nd April 1926.)

Members of the Fifth Indian Mathematical Conference:

It is my proud privilege to convey, on behalf of the members of the Reception Committee and of the wider public they represent, a cordial welcome to you to the scene of your labours, this City of Bangalore, this chosen abode of Science, the venue of so many Conferences and Congresses of learned Societies in recent years. As the home of the Indian Institute and of a University College of Science, and as the headquarters of the Mythic Society, Bangalore harbours humanistic and classical culture no less than the natural and physical sciences, being in the same happy position as your favourite pursuit, Mathematics itself, which has always been famous as a bridge between the humanistic and naturalistic disciplines. But the greater the claims of this City, the greater are our obligations as hosts, and this makes me the more conscious of our many shortcomings in catering for our guests, assembled as they are from distant parts of India, from provinces geographically far apart though knit close in Congress and Conference by a common devotion to a common ideal. But in the midst of my trepidations, I fain remember the happy detachment and abstraction of mind bred by your favourite study, the Science of Mathematics, and I fancy that your souls will be too absorbed in the contemplation of the *n*-dimensional world and of the relativity of space-time to be distracted by the appeal of this poor three-dimensional body and its absolute pretensions to creature comforts. But in truth my appeal is to your abounding charity which I pray will take the will for the deed, and make up for *our* manifold defects by *its* own generous excess.

Gentlemen, the early annals of Mathematical Science and the history of this Indian sub-continent, and more especially of this South Indian peninsula, are too closely associated not to give rise to a train of acute reflections on the present occasion. In Mathematics, as in every other Pure Science, two great culture

series have emerged in the world's history, with many points of fruitful contact, the Indo-Sino Japanese Series and the Graeco-Romano-Teutonic series, and each has evinced distinctive traits, more especially in the domain of Mathematical concepts and analysis, which cannot fail to be recognized by the historian of Culture. For example, if we turn to contemplate the original fountain-heads of these two steams of culture in India and Greece, it would be no difficult task to establish the following facts :—

Firstly.—India has evinced more of intuition in the formation of mathematical concepts and symbols, Greece has evinced more of the ratiocinative and deductive faculty.

Both these mental gifts are of fundamental import in the Science of Mathematics; indeed they are in evidence in every Science. For in all Science, after the empirical and before the positive or quantitative stage, there comes a formative period where scientific concepts emerge, and the empirical data are subsumed either by inductive classification of particulars and synthetic generalisations, as in India. or by analytical deduction from the general to the particular, as in Greece.

In the physico-chemical speculations of ancient and mediaval India, especially as regards the structure of the atomic and infra-atomic particles (*Paramanus* and *Tanmatras*,) and their genesis from the primordial matter(*Bhutadi*), certain concepts were thus intuitively reached, by sheer dint of concentrated thinking on the empirical data of observed physico-chemical changes and transformations,—and it is no exaggeration to say that they contain surprising anticipations of the modern theory of Electrons and atomic structures ; and indeed the size of a Paramanu as given in these ancient tables is fairly comparable in order of magnitude with our recent determinations of the size of the hydrogen atom. Similarly in the domain of Mathematics, the Indians happily conceived the symbol for the zero, the decimal notation, the infinite number, the negative root, the algebraic symbols for variables, the *Kuttaka* in the solution of indeterminate equations, the *Lostraka Prastara* (for permutation and combination) the *Sinjini* or Sine in relation to the arc, the circular, spherical, pyramidal measurements and their elements, the *Nireayanevindu* and the cyclical character of the precession of the equinoxes, all these being shot out of the

Vision and the Faculty Divine, without being spun out by the ratiocinative process,—which was exactly opposite to the Greek way o proof from axioms and postulates. And this intuitive trait has persisted to this day, witness Ramanujan who evinced it in a marked degree. But the mathematical doctrinaire and precisian confounds intuition with empiricism, and suspects that the Indians received their mathematical tables and formulæ from the Greeks and Arabs wherever they do not give the proof. The doctrinaires forget that scientific method is not necessarily Greek.

Secondly—The Indians had the sense of numbers and numerical proportions remarkably developed,—the Greeks the geometric sense. This distinction has its neural basis,—it is in the last resort a matter of ganglionic centre, of cell and neuron. The Hindu naturally applied the calculus of numbers to geometrical ratios, in other words they algebraised geometry, and they also developed a more natural and more fruitful trigonometric practice than the Greeks; the *Sinjïni* and other trigonometric functions were referred to the relations of arcs and chords, and were thus based in truth on circular measures.

Thirdly.—The Indians had a greater command over general symbols, and therefore a purer and more general algebra than the Greeks who kept their theory of numbers and their geometry more or less apart. The claim to co ordinate geometry on behalf of the Greeks cannot indeed be sustained, but it was the Greek triumphs in the geometry of conics which laid the foundation for modern scientific astronomy; and the Diophantine analysis showed the native Hellenic power even in numerical problems, but the generality of the Indian *Kuttaka* was wanting.

Fourthly.—The Greek Astronomy was more deductive, and the Indian more practical. Not that Thibaut was right in thinking that the Hindu astronomer had no clear notion of epicycles and eccentrics, having borrowed the theory from Hellenic almanack-makers or clock-makers. The fact was that the Indians saved the appearances, to use the astronomical parlance, by a different notion of eccentrics, which in relation to the mean motion of the planet's centre was simpler and more direct. And the alleged backwardness of the Indian astronomical tables is based on a misconception. In the matter of the lunar constants entering into

calculations of lunar periods and eclipses, the Indian tables are far more correct than any Greco-Arab computations, and if the planetary motions are referred to the *Nirayana-vindu*, as conceived by the Indian astronomers, they would be seen to evince the same degree of accuracy.

Fifthly.—The triumphs of Archimedes in Statics and Mechanics and of Appollonius and Pappus in Conics laid the foundation for future advances in a number of physical sciences. But the Greek Dynamics was futile. The Hindus had better concepts in Kinetics and Dynamics. They had a rude anticipation of the first law of motion, of course in the pre-Einsteinian and pre-Lorentzian form—they made also an acute analysis of the concept of force, distinguishing between *Vega* (momentum), *Nodana* (impulse), and *Abhighata* (impact)—they also analysed vibration, and conceived wave motion, distinguishing in a tentative sort of way between two kinds of waves, transverse and longitudinal (*Kadambagolaka* and *Vichitaranga Nyaya*). But the Greek work on the angle of reflection and that on the centre of gravity were far superior to the Indian ideas in these subjects, though for the latter the Indian Shilpa-shastra in its practical directions gave very good empirical rules.

Sixthly.—Archimedes' anticipation of integration was matched by Bhaskara's of differentiation. For Bhaskara not only used the equivalent of the formula $d(\sin \theta) = \cos \theta \,.\, d\theta$ but also in computing what he called the instantaneous motion of a planet, measured the differential of the planet's longitude, and his process not merely bears a strong analogy to the corresponding process in modern mathematical Astronomy, as Spottiswoode notes, but is virtually identical with that of the differential calculus, as I have elsewhere shown.

An application of a calculus, identical with the differential calculus to an astronomical computation shows how far Bhaskara was advanced in this direction.

Seventhly.—The Indian sense of number gave the Indian mathematician an intimate sense of time, of moments (*Kshanas*) and of the time-continuum (*Kala*), even as the Greek sense of space gave the Greek geometer an intimate sense of points and lines. The result is seen in the Indian concept of the *Kshana*, the ultimate unit of time which is defined in the Indian Sankhya by

the instantaneous transit of a *Tanmatra* ('electron') from one position in space to the next succeeding position, and in the Vaisheshika as the time during which motion exists in a *Paramanu* (atom or electron) *prior* to its disjunction from another *Paramanu*. The number of such units will determine the time interval between a given set of physical conditions and a particular effect, for between a so-called sum of causes and a so-called sum of effects there intervenes a series of atomic (or molecular) motions, with conjunctions and disjunctions which form the causal chain. This is suggestive of a time-calculus.

But the Vaisheshika still holds to absolute time. The Jainas transform this concept of the ultimate time-unit by placing it on the basis of Relativity. They distinguish between Real Time which is duration, and Applied Time, which has for its marks change, motion, and succession or simultaneity. They hold that Real Time, as much as Applied Time, as much as the time which measures change, motion and simultaneity or succession, is manifold (*aneka-dravya*), and differs for every different Pradesha (local system), every different division of Akasha. But Vachaspati suggests a *via media* between the concepts of absolute and relative time by introducing the concept of *gati-kshana-prachaya*, condensation or rarefaction of time in a moving body, a sort of relative motion-time in place of the Jaina concept of what may by analogy be called the relative space-time (*bhinnabhinna-pradeshastha samaya*).

The Greek doctrine of Relativity was logical and epistemological, but was not carried into the field of Mathematics. Zeno indeed was the first to moot the problem of relativity of time in his questions, but this problem remained insoluble to the Greeks. The Indians with their number-and-time sense developed the concept of Relative Time, and suggested a time-calculus for physical causation.

Gentlemen, the history of Indian Mathematics as usually written ends with Bhaskaracharya. But as I have said elsewhere, the progress of Indian Algebra (mainly in South India) after Bhaskara, parallel to the developments in China and Japan is a subject that remains for future investigation.

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I will illustrate the possibilities in this direction by a single interesting example.

Take the value of π for instance. From Bhaskara's value of π correct to four decimal places to the value given in a South Indian compilation, the Sadratnamala (circa 1530), which is correct to *more than a dozen places,* there remains a gap which cannot be bridged over at present. Nothing like this was available in Europe before the days of the Bernouillis. But the Chinese in the 13th century had reached a value of π midway between these two Indian determinations, and in that age imperial embassies from China to Ceylon and to the South Indian kingdoms were not unknown. A century later, an Indian manuscript notes a value of π correct to about 30 decimal places. And the sums of two infinite series, the inverse squares of the natural numbers and of the odd numbers, are given in terms of π^2. This was in the beginning of the seventeenth century. The genuineness of these entries has been doubted ; but by that time, as we know, a great development in the summation of infinite series (including trigonometric and exponential series) had been achieved by the Japanese mathematician Seki and his disciples, perhaps not without some contributory influence from the University of Leyden. But neither China nor India then shared in that development.

But, gentlemen, a strange phenomenon, or rather two strange phenomena, have shown that there has been no lapse of continuity in the Indian mathematical mind. The conscious group-mind cerebrates still, and like the seed in the Egyptian mummy, retains its old fecundity. For so late as in the early nineteenth century, an Oriya Pandit, Chandra by name, in the jungles of Orissa, by the crudest instruments, improvised of bamboo, carried on astronomical measurements, which in their range and precision spanned a great part of the arch of astronomical progress from Ptolemy to Tycho Brahe. And further South, a poor under-fed clerk in the Madras Port Trust Office, manifested the same phenomenon of secular progress in the race mind. Ramanujan, I say, represented in his person not an individual but a race. In his person, independently, the Indian national mind spanned the gap between the age of the Sadratnamala on the one hand, and the era of Euler and Lagrange on the other.

This leads me to hope for great things from India's co-operation, a co-operation just begun, in the contemporary movement of mathematical thought. Of the two great types of mathematical minds, the type that finds new functions and symbols for given facts, and the type that finds concrete facts for functions and symbols conceived in the abstract, it appears to me that India is happily endowed with both. Again, taking the more conventional distinction between Pure and Applied Mathematics, if we have a Ramanujan for the former, we have, though at a considerable distance, a Raman and a Meghnad Saha for the latter. Indeed, the cultural environment in Bengal appears to favour the application of mathematical functions to physical problems,—that in Madras favours the delight in pure forms and their rhythmic procession. But of one thing I am certain, the two most original advances in the Mathematics of to-day lie in directions which have a peculiar fascination for the Indian mind. On the one hand, the Logic of Mathematics, with special reference to the concept of class as applied to numbers, as well as the entire development of numbers, sets of points, aggregates and fields (after Cantor and Dedekind); on the other hand, the Relativity Theory with reference to space-time and the four-dimensional world—are new developments which offer a challenge to India's generalising and synthetic intelligence, as well as to India's rhythmic sense of sets and sequences, and perhaps it will be the Indian mind which will one day formulate a more general principle than Einstein's general principle itself. That highest law of relativity will perhaps subsume Einstein's general principle as a special case, and will find not four dimensions of space-time, but a world which in truth is indefinitely manifold in its dimensions yet capable of being presented, in relation to the observer's unfolding sense-endowment, as a world of one, two, three, four, five, six or more dimensions, in indefinite sequence, and capable too of being computed and analysed more and more accurately according as we increase the number of dimensions. It may be that just as Euclidean geometry and Riemannian space, Newtonian mechanics and Lorenzian dynamics are now seen to be imperfect and inaccurate presentations of the real world, even so Einstein's four dimensional world of space-time will be presently seen to be a mere simplification, under hypothetical assumptions

and postulates, an approximation which is no more final than Euclidean space or Newtonian mechanics. Not even the general theory of relativity can to-day be pressed to the explanation of Quanta, or of Bohr's atomic structures, and even as regards the relations of mass and energy in electro-magnetic fields Meghnad Saha has already applied a correction or supplement. We must never forget that the one given fact is that of motion, and that the concepts of mass, energy, space, time, whether assumed to be absolute or relative, have to be adjusted from time to time to explain the observed facts of motion. Perhaps a five-dimensional system, three of space and two disparate and incommensurable dimensions of time in the form of synchronousness and sequence, may interpret the phenomena of motion (including those relating to the velocity of light) better than a four-dimensional scheme of a relative space-time, and ultimately even a sixth dimension in the shape of mass (or of energy) may help to smooth the discontinuities formulated by Plancke and Bohr. In fact, if Dayton Miller's observations of an ether drag should be finally established, not only the special theory of relativity, but even the general theory in part, will have to be abandoned, by Einstein's own admission, and it will then be high time to seek a higher generalisation still by adopting a five-dimensional or six-dimensional scheme as just adumbrated. In fact, a n-dimensional manifold, where n is indefinitely large, would give an absolute form to a world of relative appearances, and this is the ultimate view of the Universe to which we are drifting. And thus as the background of this unfolding order of time, this projection of Maya, we have a glimpse of the rational order in the Absolute.

Report by
Rao Bahadur P. V. Seshu Aiyar, Hon. Joint Secretary.

MR. PRESIDENT, LADIES AND GENTLEMEN:

On behalf of the Managing Committee of the Indian Mathematical Society, I have very great pleasure, and I consider it a proud privilege, to extend to you all a hearty welcome to this Confercnce. We are profoundly thankful to the members of the Society and to other distinguished mathematicians who have come from all parts of the country to attend this Conference which is intended to promote the advancement of Mathematical learning and research. We are also thankful to the many citizens of this historic city of Bangalore who have responded to our invitation by gracing this occasion with their encouraging presence. We have been fortunate enough to enlist the sympathy of His Highness the Maharajah of Mysore who has been graciously pleased to send a message of encouragement to this Conference. We are specially thankful to Dr. Seal for the hearty co-operation and help he has rendered us in the midst of his multifarious duties as the Vice-Chancellor of the Mysore University. Lastly we take this opportunity of giving expression to the grateful thanks of the Society to the various Local Governments, Native States, Universities and Institutions for the facilities they have granted to their officers, to enable them to attend this Conference.

Since its formation by Mr. V. Ramaswamy Aiyar in 1907, the Society has been growing in strength and usefulness under the wise guidance and direction of its successive Presidents, the late Mr. B. Hanumanta Rao, the late Mr. Middlemast, Dewan Bahadur R. Ramachandra Rao, Principal A. C. L. Wilkinson (now retired) and Mr. Balak Ram, I. C. S. In accordance with a keen desire expressed by many of our members and to increase the usefulness of the Society, a Mathematical Conference was held under its auspices for the first time in Madras, in December 1916. The Conference was opened by His Excellency Lord Pentland, the then Governor of Madras,

and Principal A. C. L. Wilkinson delivered the Presidential Address. The success of that Conference and the keen interest evinced by the members induced the Managing Committee to arrange for periodical conferences and accordingly the second Conference was held in Bombay in January 1919, the third in Lahore in March 1921 and the fourth in Poona in April 1924.

Since there are many gentlemen of the Mysore State enrolled as members of the Society and since Mr. M. T. Naraniengar of this City has been actively connected with the Society as the Editor of its Journal ever since its inception, it was thought that Bangalore was appropriate for the Fifth Conference. Accordingly Dr. Brajendranath Seal, the Vice-Chancellor of the Mysore University and Mr. M. T. Naraniengar were consulted about the holding of a Conference here. As Dr. Seal was on leave, no definite decision could be arrived at before December last. We are thankful that, as soon as he returned from leave, he took up the question in right earnest and wrote to us that though it was a little too late for the University of Mysore to invite the Indian Mathematical Society to hold its Conference here, he himself and other members of the management of the University would be glad to do individually all that lay in their power to make the Conference a success. On that assurance, it was definitely decided to hold the Conference here and subsequently Dr. Seal also secured for us the sympathy and support of His Highness the Maharajah whose Message we have just listened to with respectful attention. We take this opportunity of conveying to him and to His Highness the Maharajah our respectful thanks for their kindness and encouragement.

It may serve to show the interest evinced by our Members in these periodical Conferences if I mention that—

at the 1st	Conference	we had	13	papers	contributed by	11	authors
,, 2nd	,,	,,	16	,,	,,	16	,,
,, 3rd	,,	,,	15	,,	,,	13	,,
,, 4th	,,	,,	28	,,	,,	20	,,
while for the present	,,	,, have	30	,,	,,	23	,,

At this Conference, we have also arranged for a discussion meeting and two public lectures. Thus it will be seen that these

periodical Conferences, apart from their other advantages, serve as a good incentive to our members to attempt original work. And it is hoped that with the help and patronage of Local Governments, Native States and Universities, we shall continue to hold our Conferences regularly once in two years at different centres of learning.

During the two years that have elapsed since we last met at Poona our Society has fairly maintained its strength. In 1924, our strength was 223 consisting of 8 Honorary members, 10 Life-members and 205 Ordinary members. The present strength is 219 consisting of 8 Honorary members, 12 Life-members and 199 Ordinary members. It is hoped that with the co-operation of our members in making our Society more widely known and in getting more members enlisted, the strength of the Society will increase in future.

At the business meeting of the last Conference at Poona, a Committee was appointed to go into the question of the circulation of Journals and suggest improvements. In accordance with its suggestions rules were framed which it is hoped have secured a more satisfactory circulation. Prof. V. A. Apte deserves special mention in this connection for devoting his time and energy to the work.

Another Sub-Committee was formed to arrange for completing the sets of leading mathematical periodicals subscribed for by our Society and I am glad to be able to report that a sum of Rs. 6,000 has been utilised for the purpose and that our Society now possesses complete sets of many of the leading mathematical journals. In this connection, the exertions of Mr. N. M. Shah, who has been recently elected Secretary of the Society as my successor, deserves special mention.

Another resolution passed at the business meeting of the last Conference recommended that the concession rate of subscription might be extended to members drawing a salary of Rs. 250 or under. At present, the concessional rate is allowed only to those whose salary is below Rs. 100. The Committee gave its best consideration to the subject and resolved that under the present financial conditions of the Society the concession rate could be extended only to those whose salary is not above Rs. 150. These and other questions will be placed before the business meeting to-day for consideration.

Address to
Mr. V. Ramaswami Aiyar, M. A.,
Founder of the Indian Mathematical Society.

SIR :

The Indian Mathematical Society under whose auspices we are assembled in Conference to-day completed its eighteenth year of existence last year, and according to Indian reckoning attained its majority. On this important occasion, we, the Members of the Society, feel it our pleasant duty and privilege to present you, its Founder, with this Address in token of our great appreciation of your labour of love.

In this connection, it may not be out of place to review briefly the history of the Society. On the 25th of December 1906, you conceived the happy idea of addressing a few friends interested in Mathematics to form an "Analytic Club" for the purpose of securing facilities for advanced study in that subject by way of mathematical books and periodicals. About twenty gentlemen responded to the invitation, and the formation of the Club was announced in the Madras papers on the 4th of April 1907. The original idea was only to subscribe for periodicals, purchase the latest books connected with mathematical research, and arrange for their circulation among the members. But even in those early days, you, Sir, cherished larger and higher ideals for the future of the Society—such as greater Equipment, the conduct of a Mathematical Journal, and the formation of a Central Library. Notwithstanding your arduous duties in other directions, you spared no pains to promote the growth and usefulness of the Institution. By issuing circular after circular, you had a suitable Constitution framed for the Society, and placed its affairs on a secure basis before you laid down the office of Secretary. It may not be out of place to mention that with the true scholar's freedom from provincial bias, you, a

Madrasi, arranged to locate the Head-quarters of the Society at Poona, in the Bombay Presidency—a step which gave our Society the unique position of being an All-India Institution.

It is impossible to overstate the difficulties that you had to encounter in nurturing your infant creation and enabling it to grow to lusty youth. The members were scattered all over India. They were not acquainted with one another sufficiently enough to arrive at a common understanding and to tone down the inevitable differences of opinion. Undaunted by these difficulties and in spite of the pressure of your official duties, you carried on the work of the Society successfully, arguing, remonstrating and pleading; and though the work had often to be done in the late hours of the night, you were never dilatory in your efforts to secure the speedy realization of the aims of the Society. In a few years, you succeeded in building up a Library and starting a Journal. In 1907, the membership of the Society was only 20. It had no Journal. At present, it has 219 members and 49 subscribers ; its Journal is running through its 16th volume ; its Library has a large stock of books ; it subscribes for a decent number of mathematical journals, and is in intimate touch with similar Societies in the world.

We are proud of this achievement ; and if, to-day, the Society occupies a position well-recognized in India and in the mathematical world outside, we feel, Sir, that it is in no small measure due to your initial labours to place it in working order and to promote its advancement in all directions. The Society has already enrolled you as an Honorary Member and at this public Conference, in this eventful year of its existence, we beg to tender our loving tribute of appreciation and gratitude to you, its Founder, for all that you have done to bring it to its present position of vigorous life and activity. When you retired from the Secretary's post, there was a general feeling that you should be elected President of the Society, but with your usual modesty

you declined the office not only then but on every subsequent occasion. We are glad that you have at last yielded to our wishes, and consented to be the President for this term.

May the Society flourish under your care and may a long and happy life be vouchsafed to you!

We subscribe ourselves,

Sir,

Your Fellow-Members of the Indian Mathematical Society.

The Presidential Address

DR. SEAL, LADIES AND GENTLEMEN :

The Indian Mathematical Society and its Committee have honoured me this year, in a three-fold manner, for my humble services, done over 18 years ago, in founding the Society: first, they have made me an Honorary Member of the Society ; secondly, they have raised me to the position of the President of the Society; thirdly, they have presented me with a beautiful address, which makes this a red-letter day in my life.

Under the constitution the Committee can elect as Honorory Members persons distinguished in Mathematics, or in eminent positions and interested in the objects of the Society. I do not see that the Committee have made a strict application of the Rule in electing me an Honorary Member. They have simply expressed an exceeding good-will towards me as founder of the Society. By their act, they have put me in one list with such eminent *Acharyas* of the Science as Baker and Hardy, Whittaker and Whitehead, and such a distinguished son of India as Dr. Paranjpye. To such a list I feel my name has been added very unworthily.

Since our last Conference we have lost from this list, by death, the brilliant name of Sir Asutosh Mukherji, M.A., D.L., C.S.I., who was fitly styled as *Saraswathi*. He was eminent in many a field of knowledge besides Mathematics, and his great services in the cause of scientific advancement in India can never be forgotten.

The Presidentship of our Society has been held before me by such distinguished scholars as Prof. Wilkinson and Mr. Balak Ram. They represented the Bombay and the Panjab areas of our membership, respectively. By an unwritten convention, the Presidentship, it appears, should go now to one from the Madras side. When I was offered the place, I expressed my dissent from this convention as Mr. Balak Ram was holding it very worthily ; and I also said that, if the convention must be followed, the honour should go to a veteran mathematician like Mr. Naraniengar. But Mr. Seshu Aiyar,

the energetic Secretary, would not be deflected from his purpose. He said that Mr. Naraniengar was still wanted as Editor of our Journal, that I must take the Presidentship before it can go to younger men, and that the Committee's wish to see me honoured in this way, must be respected. I found myself not strong enough to resist further, and I accepted the nomination.

The Committee have further honoured me with their very kind address read to-day. In every previous Conference I have been mentioned to be the founder of the Society and therefore a special address to me now, on the fortunate circumstance of my being the founder, is really superfluous. But, as an expression of the good-will of the members towards me, I value it greatly and shall cherish it deeply. It is moreover a happy circumstance, Sir, that it is given to me to receive this address, standing on Mysore soil. For it was in Bangalore and Mysore that, years ago, I had a short spell of service as a Mathematics teacher—a period which I remember with great pleasure. I wish to thank the Committee and members of the Society very sincerely for these several honours which they have bestowed upon me.

When I accepted the Presidentship I did not realize that the task of a Presidential Address at this Conference was to be mine so soon. I am very ill-fitted for the task. My life has been cast in a different sphere of work and away from any Mathematical Library. I own but few books and even these I have left behind in one of my previous stations. Both Messrs. Wilkinson and Balak Ram have, in previous Conferences, given us most scholarly addresses, the level of which it is imposssible for me to reach. Casting about for ideas I have thought of making up my address by placing before members some of my own mathematical reminiscences, which, if you are indulgent enough, may show the nature of the interests that the founder possessed ; and, along with them, a few observations of a general character regarding the progress we can make for attaining the general objects of the Society. It is an amateur's address, and I hope for your utmost indulgence.

Before I proceed further, it is my duty to pay a tribute of respect to Messrs. Balak Ram, Seshu Aiyar and Ross for their services in general and as members of the last Committee.

When our Society was formed in 1907 its membership was confined to the Madras and Bombay areas. But soon afterwards Mr. Balak Ram was introduced as a member by Dr. Paranjpye. Mr. Balak Ram was a fine product of the young University of Punjab, and, ever since he joined, he has been a pillar of strength to our Society. He soon got in for us many members from Punjab. The Calcutta Mathematical Society was under formation at the time and there were reasons to fear that the Punjab area would go over to the Calcutta Society as Punjab formed a part of the extensive area of the old Calcutta University. But Mr. Balak Ram made that area safe for our Society. He has performed for us the mathematical annexation of the Punjab. Not only so, but during his Presidentship our Society reached a world-wide standing coming in contact with all the sister institutions in the world. Our Journal made a marked progress in his time, in keeping with the advance in our Society's standing. To crown all, he has made us a princely benefaction of Rs. 1,000 to our Library. To this benefaction I shall have occasion to refer again. It is one that our Society can never forget. I am so glad that Mr. Balak Ram, though he has laid down the office of President, continues to be a member of the Committee.

I have next to express my great regret that Mr. Seshu Aiyer has gone out from the Committee. He has given his best services to the Committee now for over 15 years. He had a rare touch with the men in all districts of Madras who were engaged in mathematical teaching in High Schools and Colleges. Year after year, also, there were batches of young men who studied Mathematics under him in the Presidency College, Madras. He has brought in many of them as members of our Society. To Mr. Seshu Aiyer is due the credit of organizing our first Conference in Madras, which proved a great success. When he proposed the Presidentship to me, he kept away from me the fact that he was going to be off from the

Committee. Had I known it, it is nearly certain that I would have preferred to be outside the Committee, too. But, a good tactician, he has fixed me in first, and then got himself out, mentioning our rule of rotation, and various circumstances as excuse. But though outside the Committee, he has promised me, that his endeavours on behalf of our Society will continue unrelaxed. The Government have honoured him with the title of Rao Bahadur which he deserves by his work for our Society alone.

I regret also that Prof. Ross ceases to be in the Committee under the rule of rotation. His breadth of mathematical scholarship, especially in the field of Analysis, is second to none. His genial character and his fine spirit of fellowship with Indians are known to all who have come in contact with him ; and I feel that, by his retirement, the Committee have lost a most valuable member.

I must now turn to the promised mathematical reminiscences of the founder. In 1893 I took the M.A. degree. In the following year, about August, I was a candidate for the Mysore Civil Service Examination and failed. But I then received an enquiry from Mr. Bhabha, Inspector-General of Education in Mysore, asking if I would act as Professor of Mathematics in the Central College, Bangalore, in the place of Mr. T. R. Venkataswami Naidu, who was taking a short leave. I was glad to accept the offer. This made me a colleague of Mr. M. T. Naraniengar and we became intimate friends. Mr. Naraniengar had passed the M. A. in the year previous to mine. We were both deeply interested in Mathematics. Geometry was our *forte* (in a modest way), and curves, our particular fancy. Mr. Naraniengar and myself used to take long walks together in the mornings, in the bracing climate of Bangalore, discussing, I think, nothing but Mathematics. Ball's *Mathematical Recreations* had recently come out and contained a lot to interest us. I wonder how often we stopped in the road to draw and discuss a figure, careless of mankind passing by. After Mr. Venkataswami Naidu rejoined duty, I continued to remain in Bangalore, meeting him frequently. He was a fine conversational-

ist with shrewd remarks on nearly every topic. We had a specia affinity as both of us were old boys of the Coimbatore College. I regret he is no longer among us.

When, years later, I felt the need of a Mathematical Society in India, and sent my proposal to form one, my efforts were warmly supported by both Messrs. Venkataswami Naidu and Naraniengar. Not only were they among our foundation members, but they both came into our first Managing Committee, contributing to its strength. Our Society, when born, showed signs of rapid progress, and, not only did I know that the Journal of our Society would be started soon, but I knew also precisely who was going to be its distinguished Editor. Mr. Naraniengar has carried on the work of our Journal very ably during 18 years and, for this labour of love, we cannot be too thankful.

Proceeding with my reminiscences, in 1895 Mathematics classes were opened for B.A. in the Maharaja's College, Mysore, and I was appointed to a permanent post in the staff of the College, as Lecturer in the subject. Mr. J. Weir was the Principal of the College and Professor of Mathematics. I became his assistant. Mr. Weir got me introduced as a member of the Edinburgh Mathematical Society and I felt very proud to become a member of that body. The proceedings of the Society, which I received, gave me my first glimmer of hope that a Mathematical Society like the Edinburgh could, perhaps, be formed in India. I spent a happy year in Mysore, teaching Mathematics. I remember very well the room in the college that was given to us, Assistant-masters and Lecturers. It was an institution by itself. Men teaching different subjects, we met daily in the interval for lunch. In that company which included the Sanskrit and Kanarese Pandits, I used to feel very happy, and realised that every branch of learning was a means for a great culture : and Mathematics was surely, but only, one such branch.

One very interesting reminiscence of that year is my becoming private tutor in Mathematics to Miss Bhabha, daughter of the

Inspector-General of Education, who was studying for the Matric. Miss Bhabha, I learn, afterwards became Lady Dorab Tata. I have not met her as Lady Tata and the image in my mind is that of Miss Bhabha only. Miss Bhabha did everything gracefully. Her note-books were a model of neatness. Once, when I was taking her over the theorem of Pythagoras and discussing some *extra* proof of it, she brought to my notice an interesting little figure, which had a neat property. She proved it one way and I showed another way of doing it. Between these lay the proof of a particular case of Euclid, I. 47. Varying the figure a little, both our modes of proof applied for proving a like property of the new figure; and that meant, we found out a new proof of Euclid I. 47. I communicated this proof to Mr. Venkatasami Naidu at Bangalore, who sent me an observation thereon. This led me to see that the principle of the proof that Miss Bhabha and myself had found had a wider application, and that it yielded a proof, *within the First Book of Euclid*, of the theorem that a regular figure of n sides described on the hypotenuse of a right-angled triangle was equal to the sum of the regular figures of n sides described on the other two sides.

My service in Mysore did not continue long. I appeared for the Madras Civil Service Examination of 1895 and came out successful—thanks to my friend Mr. Belwadi Dasappa, the Lecturer in English, who coached me in that subject in which I was very deficient. I left Mysore with great regret, for, not only my work as Mathematics Lecturer, but the life with the students, the scenery and traditions of Mysore, and the work of its statesmen, all filled me with interest; and Mysore was to me emblematic of all the glory of our motherland. I joined the Madras Civil Service as a Deputy Collector at the end of 1895.

Taking a step forward now of about 12 years we come to 1907, the year in which our Society was founded. But, to give an account of the circumstances which led to the formation of our Society, we must go back to the previous year 1906.

The year 1906, I think, is an important date in the intellectual history of the world. It was the year in which Einstein made his

great discovery of the principle of Relativity. It was also the year, probably, in which our own great mathematician, Ramanujan, unknown as yet, was making some of his discoveries. However that be, there was a feeling in India that it was the time of a large awakening. There was considerable political agitation then, owing to the partition of Bengal. But men also saw that, before India could become great, we needed advancement in many different directions. Our great countryman, Sir J. N. Tata, had these problems in mind and had laid the foundation of a considerable industrial and intellectual advancement. But his great scheme of a Central Research Institute for India made no provision for mathematical advancement. One day I put myself the question " Can I not be of some help in advancing the interests of Mathematics in India." The spirit of the times made me think seriously about the question. I wanted to form a Mathematical Society which might be something like the Edinburgh Society. I obtained the Calendars of the Madras and Bombay Universities and made a list of all the men who had taken the M.A. degree, or a first class in B.A., or were doing work as Professors and Assistant Professors in the various colleges. The list was very encouraging. There were men of distinction like Dastur, Sanjana, Apte and Paranjpye in the Bombay Presidency. There were men like Hanumantha Rao, my own teacher Swaminatha Aiyar, Ramachandra Rao, Naraniengar, Ramesam, Venkataswami Naidu, and so on, in my Presidency. On perusal of the long list, it occurred to me that, if by some magic, I could only put all these names into a Society, then, with Euclid, I might say, Q. E. F. (what is required is now done). But I did not see my way for this magic. I was a Deputy Collector and not a Professor of a College whom his fellow mathematicians would know. I sometimes thought that, if I were the great Asutosh Mukherji of Bengal, I could make a trumpet call, bringing all the mathematicians together at once. But I was unknown ; and any call by me, I felt, would fall flat on the public ear. So I was in a state of hesitation as to the action I should take.

In that year I saw a copy of the quarterly journal of Mathematics, sent me by a friend. The matter which it contained was

mostly beyond me but there was a little bit which delighted me And I began to wonder how many such delightful bits, we in India may be missing by not seeing the leading journals. This made me more eager than ever to try to form a Mathematical Society. At length came the Christmas Day of December 1906. I was put up in a village *Chavidī*, in Gooty Division, Anantapur District. Thinking calmly, I felt that God will prosper any earnest endeavour made in a self-less cause. I was able to see my plan clearly and I wrote a little letter asking friends to join and form a small Mathematical Society. The letter was simply conceived and had no ambitious programme. It has been published in Vol. XI of the Journal of our Society. I sent copies of the letter to one friend after another and I received an abundant response during three months. Then on the 4th of April 1907, I was able to announce in the Madras dailies that the Society was formed, with a strength of 20 members, under the name " The Indian Mathematical Club," and I became one of its Joint Secretaries along with Mr. Naraniengar and I continued so till 1910. The strength of the Society had grown then to about 120. This period of service in the cause of Mathematics is one which gives me great pleasure to ook back upon, and your generous recognition of it to-day fills me with thankfulness that it was given to me to render the service.

After the formation of our Society in 1907, I wrote to the leading mathematicians of Bengal (with copies of my original letter and letter of announcement) asking for their support. I got a prompt response from Professor Mahendra Nath De, but not from others. Prof. De informed me that my letters to others had been received, but the mathematicians of Bengal were considering the formation of a separate Society in Calcutta. I was feeling disappointed that Bengal did not join us. Before long, however, I received a kind letter from Sir Gurudas Bannerji, the eminent Judge, as well as mathematician, acknowledging my letter, commending our action, and stating that they in Bengal preferred to have a Society formed in Calcutta itself, to gain our common objects the better, and that plans for this were ready. He said that

India was such a vast country that there was ample room for both the Societies to function and he wished all prosperity to our endeavours. With such blessings from Sir Gurudas we were very glad to see our sister Society come into existence in Calcutta, in 1908, for promoting our common objects. The thought has sometimes occurred to me, Sir, that if I have been the positive founder of our Society, I am also a sort of *negative* founder of the sister Society at Calcutta.

The year 1910 holds a special place in my mathematical reminiscences being that in which I met Ramanujan, that brightest flower of Indian Mathematics which has been plucked away so soon from the bosom of Mother India. Ramanujan, as yet unknown to the world, came to me at Tirukoilur, with a letter of introduction from Mr. K. S. Patrachariar, member of our Society. The letter said that Ramanujan had great abilities in Mathematics which, Mr. Patrachariar suggested, I would be in a better position to appreciate. Ramanujan stayed with me 3 days. I then had a view of those remarkable note-books in which he had recorded the numerous results of his discovery. There was little or no explanation given but the results were of a very striking character. I put him some test questions in order to find out if his methods were really based on sound principles. I remember one such question. Taking the harmonic series $1/2 + 1/4 + 1/6 + 1/8 + \dots$ formed with the even natural numbers and the harmonic series $1 + 1/3 + 1/5 + \dots$ formed with the odd natural numbers, my question was to show that the sum of $4n$ terms of the former series exceeded the sum of n terms of the latter series by an amount which constantly diminished as n increased and vanished as n became infinite. I asked Ramanujan to let me know if this was true. He soon said it was. I asked him for his method. He gave it and I observed it did not require the use of the Euler Constant. When I told him that my method required the use of the Euler Constant, he observed that both the series were plain enough in their meaning and did not involve the idea of a logarithm or the Euler's Constant and therefore, intrinsically,

the result should be capable of proof without the Euler Constant, a remark which impressed me as showing a broad out-look which we discussed further. I put Ramanujan other questions involving delicate points of convergence which I had come to know in correspondence with Prof. Hardy. Ramanujan was able to grasp them quickly. I then felt convinced that Ramanujan's abilities were of a high order and that the results in his note-books must be genuine work. In the end I asked Ramanujan to let me know whether there was anything I could do for him. He said he was badly in need of employment and suggested that I might put him as a teacher in one of the Elementary Schools belonging to the Taluk Board of which I was President. I told Ramanujan that it would be sacrilege on his talents to put him to teach in an Elementary Board School but that I had been thinking out if I could not be of help to him in a real manner.

The idea that had struck me was that I should try to get Ramanujan a University Research Scholarship. I devoted anxious thought as to how this was to be done. Ramanujan was a failed F. A. and how was he to get a scholarship for research, from the University? In the end, I wrote a letter to Mr. Seshu Aiyar, then at Madras, a letter written both for him and Mr. Narayana Aiyar, the Treasurer of our Society. I said in that letter that Ramanujan had extraordinary abilities in Mathematics though he was a failed F.A., and that a University Research Scholarship should be secured for him; that for this purpose, his abilities should be brought to the personal notice of every member of the Mathematical Board of Studies (I had then the honor to be on the Board), and, with our united support, we should make an impression on the Syndicate. I wrote also that, till a scholarship was secured, some job must be found for Ramauujan to live by in Madras; and that till he got a job, friends should maintain him somehow. I asked in particular that Ramanujan's merits should be promptly brought to the notice of Dewan Bahadur R. Ramachandra Rao. Such was the substance of my letter. Mr. Ramachandra Rao, our past President, within whose bosom there beats the heart of a

true son of India, generously helped Ramanujan to remain in Madras at a time of pinch. My friend Mr. Narayana Aiyar removed the pinch by finding him a clerkship in the Port Trust Office of which he was Manager. The getting of a research scholarship for Ramanujan was, however, very difficult. But Sir Francis Spring, President of the Port Trust, and Dr. G. T. Walker, F.R.S., came to discover that there was a mathematical genius rotting in the Port Trust Office and, thanks to *their* intervention, the Research Scholarship, that I had anxiously hoped for was eventually secured for Ramanujan. After becoming a Research Scholar, Ramanujan became the architect of his own further advance by those first letters that he wrote to Prof. Hardy, giving some hundreds of his results These led Prof. Hardy to realize that Ramanujan was a mathematician of a high order; and he warmly took the steps required to get Ramanujan to go over to England for study and made his genius world known. It is the duty of our Society to keep Ramanujan's memory ever fresh, and, coupled with it, the name of Prof. Hardy.

Our Society, having attained 18 years of age, is probably now in a self-conscious stage of its progress and it behoves us to see what we can do to further advance the objects of the Society. I would first advocate that each of our younger members should try to get into intimate touch with a few others and keep an active correspondence on matters mathematical which interest them. Our members are scattered over a large area and it is necessary that we should cultivate close touch, each with as many others as possible, through the post. I may give a bit of my own experience. Two years ago, Mr. M. Bhimasena Rao wrote to me his first letter, asking me to look into a paper which he was then contributing to our Conference of 1924 Since then our correspondence grew up and I have collected Mr. Bhimasena Rao's letters, received so far into 4 little volumes which are here before you. These volumes contain some of the most highly interesting work in Mathematics that I know of and show Mr. Bhimasena Rao to be a gifted geometer. Mr. Bhimasena Rao has with him two volumes into which he has

collected the letters I wrote to him. The principal subject of our study has been a generalization of the pedal circle theory. By means of it we have been able to extend the theory of pedal and contact circles *in plano* to a spherical triangle. I think I may try to give a general idea of the subject.

Nearly a hundred years ago Feuerbach discovered the theorem that the nine points circle of a triangle touched the inscribed and escribed circles. The beauty of this theorem has attracted many to try and find out proofs, and several proofs have been given. A notable advance was made by Dr. Hart some 40 years later when he found that the inscribed and escribed circles of a spherical triangle were all touched by another circle. This is known as Dr. Hart's circle. Some 25 years later, about the nineties of the last century, M'Cay discovered an extension of Feuerbach's theorem. It is to the effect that if the join of a pair of isogonal conjugates pass through the circum-centre their pedal circle touches the nine points circle. In 1896 I discovered an extension of M'Cay's Theorem, forming so to say, an extension of the second order of Feuerbach's Theorem and published it in the proceedings of the Edinburgh Mathematical Society. In 1901 I made a further order. I was intending to write a paper about it, but it never came about. In 1906 I published a case of it, forming an extension of Feuerbach's Theorem of the third order, as a question in the *Educational Times*. In 1907 I published, also as a question in the *Educational Times*, another case deduced from my theorem of 1901, which forms an extension of the second order of Feuerbach's Theorem. About 1910, Mr. Bhimasena Rao made his discovery of a new circle connected with a pair of isogonal conjugates which he called the contact circle. He showed that the contact circle of a pair of isogonal conjugates touched the nine-points circle if their join passed through the Symmedian point. This is an interesting extension of Feuerbach's Theorem, analogous to M'Cay's. Mr. Bhimasena Rao also discovered the theorem that the pedal circle of a point P touched the nine-points circle if the sum of the angles PAB, PBC, PCA was equal to one right angle. Mr.

Bhimasena Rao afterwards found that this theorem was anticipated by Mr. C. E. Youngman. In 1917 I gave an extension of this theorem, namely, the pedal circle of any point P cut the nine point circle of ABC at an angle equal to the complement of the sum of the angles PAB, PBC, PCA. In this way several extensions of Feuerbach's Theorem, *in plano*, have been discovered. But it does not appear that any similar extensions of Dr. Hart's theorem on the sphere have been found out, though it is now some 60 years since Dr. Hart made his discovery. In our generalized pedal circle theory, we have found that it is possible to define 'the pedal circle,' as well as 'the contact circle', with respect to any pair of isogonal conjugates in a spherical triangle, in such a way that we have several analogous extensions of the property of Dr. Hart's circle. Mr. Bhimasena Rao has worked up the extension to the sphere, of my third order extension *in plano* in a very able manner; and we are now standing confronted by the question of extending to the sphere my fourth order extension *in plano*.

Mr. Bhimasena Rao who is a son of the Mysore soil is holding a small place in the Educational service of his State. When I think of his great abilities I am put in mind of Ramanujan as a clerk in the Port Trust Office. May I make an appeal to His Highness the Maharaja of Mysore, who has sent us a gracious message to-day, that Mr. Bhimasena Rao may be placed in a better position to make his best contributions to Mathematics? Is it necessary, Sir, that I should appeal to His Highness, is it not sufficient if I appeal to you, the learned Vice-Chancellor of the Mysore University, to give this matter your kind consideration?

The next point that I wish to place before our members, is now that our Society has grown strong during 18 years, we should try to see that not only certain branches of Mathematics, but the whole field, should be cultivated by our members, based on the principle of study in close association, that I have spoken of. The whole field is recognizable as falling into so many divisions, and sub-divisions, which are not water-tight compartments but have vital connection with one another. I should like to place before members the idea that there should be a few of us studying each of these divisions or fields. Taking any one of these fields the pro-

gress that can be made in its study will be generally as follows. First one must be eager to enter the field. At this stage he is a mere *entrant*, an *embryo*. Then, by study, he develops into a *learner*. After this stage, with some enlightenment, he becomes an *interpreter* of the subject. In this stage he sees that many of the things learnt are not essential, and are mere cobwebs in the mind. He sweeps them out and takes hold of the essential. Finally, one rises to the stage of a *master*. Here he brings a fresh light of his own into the subject, becomes a discoverer, and extends the scope of the field. We can rarely rise to be masters, but we can all be learners, and possibly rise to be interpreters, by close study All these stages of progress are symbolized by the letters of the word MILE. M is the stage of the master ; I the stage of the interpreter ; L the stage of the learner ; and E the stage of the entrant, or embryo in the subject. Applying this philosophy, in order to cultivate any particular branch of Mathematics in our Society, I would like to catch some of you, younger members of the Society, as entrants, or embryos, and put you into a compartment, stock around you all the books on the subject, find a senior member, if possible, to serve you as interpreter, and find you also a master, if possible. I want to see created in our Society many such groups of interested members, of all grades of advance, compact little groups, call them Gurukulas if you like, to study the different fields of Mathematics, so that none is neglected in our Society. Success can only be slowly realized, but we can make an effort from now to secure our progress in all branches, so to say, by MILE and MILE, that is, by means of such compact groups consisting of masters, interpreters, learners and entrants. It may be said we have not got masters, or interpreters, for many subjects. But the Committee have power to appoint Honorary Members and we can cast about the wide world for finding such men to assist us.

May we discuss Prof. Eddington as an illustration of the above theory of progress? The subject of Relativity is itself new and so, we can be sure, that, not many years ago, he was but an entrant, in the field. This eager learner soon made his own the wealth of thought created by Einstein and Minkowski, De Sitter and Weyl. He saw all this wealth in clear light, and became an interpreter ; at which stage he has given the world that fascinating exposition

of the subject, contained in his "Space, Time and Gravitation." From this stage he has had further illumination, become a master, and reached a deeper synthesis of the subject, an advance upon Weyl's theory. It is a most difficult branch of Mathematics, but, it is necessary that some of our members should try to get into its mysteries. There *are* members gifted with an insight into the subject, Mr. S. V. Ramamurthi, for example; and it gives me great hope that even this abstruse subject can be successfully cultivated in India by a band of our members.

While we should organise for the study of all branches of Mathematics in some such manner, the Journal of our Society must develop also. At present, in our Journal, different classes of matter, the Higher and the Elementary, are put in together : and they both experience a discomfort in thus travelling together. I think we should early separate our Journal into an Advanced part and an Elementary part. Neither of these should be sacrificed for the other. The former should be reserved for original work and for notes relating to Advanced Mathematics. The latter should be devoted to Notes, Reviews, Questions and Solutions and should be a journal for entrants, learners and interpreters, in the better known fields of Mathematics forming the subjects of study in Colleges. In this way our Journal will become more effective in its purpose and more appealing to all classes of our members.

Then comes the big question of the expansion of our Library. Our funds are sufficient for every purpose, but the Library. I think we may proceed to improve our Library as follows. We have the princely gift of Rs. 1,000 from Mr. Balak Ram. We should ear-mark the amount for a shelf in Mr. Balak Ram's name. The shelf may be devoted to books in a few subjects, say, Quaternions, Differential Geometry, Relativity, and Statistics which, we guess, have been specially attractive to the donor. Every book in the shelf should have a label showing the particular shelf it belongs to and contain a photogravure of its donor. We should form a shelf in the name of Ramanujan and put into it all the books relating to the fields traversed by him, Theory of Numbers, Theory of Modular Equations, and so on. The Government of Mysore are making a liberal annual grant to the Indian Institute of Science. We should appeal to them to make us also a small

gift annually. In that case we can start one or more shelves in the name of His Highness the Maharaja, every book in them showing by its label that it is a gift from the Mysore State and bearing the figure of its gracious Ruler.

The position of our Society, as regards the Library, reminds me of a recent experience of mine. I went into a village one morning and saw a middle-aged woman drawing water from a well. She had some 15 pots, placed around her feet, on the platform, and was engaged in filling them. I asked the woman what she wanted so much water for. She said she was keeping a *tsalivendra* close by. *Tsalivendra* in Telugu means a place where water is supplied to people, as a charitable act, to quench thirst. I asked her if there was need for so much water for the *tsalivendra*. She said, "Not 15 pots, Sir, but even 150 will not suffice on the *shandy* days." Then I asked her who was the good man who was doing the charity. She understood my mistake and said meekly that she was doing it all herself. Then suddenly, as if she were wrong and I were right, she said, "Sir, I said wrongly, the good man who is doing this charity is the Lord Venkateswara of yonder temple, and I am doing it in His service." I praised the good woman and said she must be feeling very happy with the work. She admitted it was a happiness to her. When I was about to go, the good woman said she wanted to make a request and asked me to kindly look into the well. I looked in and saw that the water lay very deep below and told the woman that it must be hard to draw water from that depth. The woman said she did not mind the hard work and, to explain her point, she let down her bucket into the well and showed me that it can only half fill. She expressed her distress that the hot weather was coming and even this little water would go away. She asked me that the well should be deepened. Sir, our Society is like that distressed woman, who was willing to work in God's service And as she appealed to me, I wish to appeal to States and Governments, and all the wealthy in the land, to help us to get a good Library. I appeal to them, to keep the Well of Knowledge full for us, so that we may draw and distribute, and serve to strengthen our national life; and that we may hold the banner of Mathematics aloft, as the Motherland marches to glory with the rest of the world.

Proceedings of the Business Meeting held at 2 p.m. on Friday, the 2nd April 1926.

Mr. V. RAMASWAMY IYER, President, in the Chair.

RESOLUTIONS :—

I. Mr. Balak Ram, M.A., moved and Mr. M. Vaidyanathan, M.A., seconded :

"That the Managing Committee be requested to investigate the financial effect of the following proposals as regards subscription and to report to the General Body by August 1926—

(i) Fixing a uniform subscription of Rs. 12 per annum for all members, no concessions being allowed.

(ii) Fixing the subscription at Rs. 15 per annum ordinarily, but allowing a concessional rate of Rs. 10 per annum to Members whose salary is below (*a*) Rs. 250 per mensem, (*b*) Rs. 200 per mensem, (*c*) Rs. 150 per mensem."

Carried.

II. Mr. A. Narasinga Rao moved and Mr. M. T. Naraniengar seconded :

"That this meeting considers it desirable that a recurring Research Prize called 'The Ramanjam Memorial Prize' should be instituted, and requests the Managing Committee to take the necessary action.''

Carried.

Abstracts of Papers read at the Conference.

Saturday (3rd April 1926), 8 A. M.

1. DR. S.R.U. SAVOOR, M.A, D.SC. : **Betrand's Second Theorem:—**

2. Dr. R. VAIDYANATHASWAMY, M.A., F.R.S.E. : **Pedal and Contact Circles :—**

The properties of pedal and contact circles are deduced by an examination of a general type of linear correspondence between circles and conics confocal with the inscribed conics of a triangle.

3. M. VAIDYANATHAN, M.A., L.T., F.S.S. : **Transformation of Frequency Law viewed from Functional Theory :—**

The author discusses the problem :—If the frequency law of x be $\phi(x)$ and if $y = f(x)$ be the transformation to be effected, to find the cumulative frequency of y and to examine the conditions under which the frequency law of y could be derived.

The cumulative frequency for $y < u$ being $\int_{y} \phi(x)\, dx$ the author discusses the conditions under which the derivative of this integral with respect to u, could represent the frequency law of y.

4. A. NARASINGA RAO, M.A. : **Conormal Triads and Tetrads on a Conic.**

The condition that four points in a plane may form a conormal tetrad, (the feet of four concurrent normals to some conic) is obtained in terms of the structure of the pencil of conics determined by them. The locus of points conormal with a given triad A, B, C is found to be a bicircular 7-ic with triple points at A, B, C and their ortho-centre.

Conics for which a given triad is conormal are discussed and the locus of their centres and also of the meets of the normals, obtained.

5. V. M. GAITONDE, M.A., F.R A.S. and M. G. KOTHARE : **On Inequalities in Distribution** :—

A statistical study of the First Year Arts Examination marks in the various subjects for 1924 and 1925 has been made with a view to fix upon a standard method of determining the regularity or inequality of distribution which is analytic, and would take into account the entire distribution.

6. V. THIRUVENKATACHARYA, M.A., L.T. : **Some Properties of Euler's Numbers and Associated Polynomials** :—

Defining 'Euler's Polynomials' as the co-efficients $f_n(x)$ in the expansion—

$$\frac{2e^t\,(e^{-2at}-1)}{e^{2t}+1} \equiv \sum_{1}^{\infty} \left\{ f_n(x)\,\frac{t^n}{n\,!} \right\},$$

it is shown that

$$f_n(x) = (-)^n \left\{ 2^n x^n - \binom{n}{2} E_1\, 2^{n-2} \cdot x^{n-2} + \binom{n}{4} E_2 2^{n-4} \cdot x^{n-4} - + \ldots \right\}$$

and some properties of these polynomials are noticed. Applications to divergent series involving E's are given at the end.

7. S. AUDINARAYANAN : **Conics having a common Self-Polar Triangle**:—

The paper establishes a correspondence between the conics of the net and points in a plane, and studies the relations between points corresponding to various types of covariant conics. Some *metrical* properties of coaxial conics are also derived.

8. K. SRINIVASARAGHAVAN, M.A. : **Triangles and Quadrilaterals in Multiple Perspective** :—

Triangles in triple and sextuple perspective are studied by methods of Grassman's Calculus, and some of the results are extended to polygons. Among the results proved in the paper are :—

(i) If two n-gons are in $(n-1)$-ple cyclic perspective, they are also in n-ple cyclic perspective.

(ii) There exist sets of four triangles of which any two are in sextuple perspective, their centres and axes of perspective forming the vertices and sides of one or other of the remaining two triangles.

(iii) With every conic S through ABC may be associated another conic S′ such that any triangle inscribed in S and circumscribed to S′ is in triple perspective with ABC.

9. N. DURAIRAJA AIYAR, M.A., B.E. : **Bi-Parabola :—**

The Bi-parabola is defined as the negative pedal of a rectangular hyperbola with respect to any point on the curve. It is a curve of degree four and class three, with one real and two imaginary cusps and touching the line at infinity in two perpendicular directions. It has the remarkable property of having a straight line as its complete orthoptic locus. A simple geometrical method of derivation of the curve is noticed. For the symmetrical bi-parabola, a number of properties are proved, showing its remarkable analogy to the ordinary parabola.

10. S. C. DHAR, M.A., Ph.D. : **Expansions of Elliptic Cylinder Function:—**

In solving physical problems, as for instance diffraction by elliptic or hyperbolic cylinders, it is necessary to obtain solutions of Mathieu's equation which vanish at infinity. Various writers have worked at the problem during the last quarter of a century, notably Sieger[1] and John Dougall[2]. They all have expressed the solutions in a series of Bessel's Harmomics.

In the present paper, I propose to investigate the solutions in a series of Bessel's Functions, the method being different from that of any previous writer.

The following result[3] is used :—

If G (η) be a periodic solution of the differential equation of Mathieu

$$\frac{\partial^2 G}{\partial \eta^2} + (A + 16q) \cos 2\eta \; G = 0, \qquad \ldots \qquad \ldots \quad (1)$$

and if further U (ξ, η) be an integral of the equation

$$\frac{\partial^2 U}{\partial \xi^2} + \frac{\partial^2 U}{\partial \eta^2} + h^2 k^2 (\cos h^2 \xi - \cos^2 \eta) \, U = 0, \qquad \ldots \quad (2)$$

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1. Sieger : *Annalen der Physik*, Bd. 27.
2. J. Dougall ; *Proc. Edin Math. Soc.*, Vol. XXXIV.
3. S.C. Dhar : " On Some Integral Equation, etc." Jour. of Dept. of Sc., Vol 111, Calcutta University, 1922.

then the periodic integral of (1) satisfies the homogeneous integral equation

$$G(\eta)=\lambda \int_{-\pi}^{\pi} U(i\,\theta,\ \eta)\ G(\theta)\, d\theta, \qquad \ldots \quad (3)$$

the kernel $U(i\theta,\eta)$ being symmetrical in θ and η and also periodic.

If we take the form of the kernel to be $J_0\{kh\sqrt{\tfrac{1}{2}(\cos 2\theta+\cos 2\eta)}\}$, the form of the periodic solution $ce_{2r}(\eta, q)$ of Mathieu's equation is found to be

$$ce_{2r}(i\xi, q)$$

$$= \lambda_r\, 2\pi \sum_{0}^{\infty} (-1)^n\ \alpha_{n,r}\, J_n\left(\frac{kh}{2}\ e^{\xi}\right) J_n\left(\frac{kh}{2}\ e^{-\xi}\right) \ldots (4)$$

where $\alpha_{n,r}$ can be found out by Dougall's formulæ[1].

But if we take $U(i\theta,\ \eta)=Y_0\{kh\sqrt{(\cos 2\theta+\cos 2\eta)}\}$ where Y_0 is Neumann's function, then we find

$$ce_{2r}(i\xi, q)$$

$$= \lambda_{2r}\, 2\pi \sum_{0}^{\infty}(-1)^n\ \alpha_{n,r}\, Y_n\left(\frac{kh}{2}\ e^{\xi}\right) J_n\left(\frac{kh}{2}\ e^{-\xi}\right). \qquad \ldots \quad (5)$$

Similarly, we can find various other forms for the periodic solution.

It will be found that the above expressions vanish when ξ is made infinitely large.

11. A. A. KRISHANASWAMY AIYANGAR, M.A., L. T.: **Orthogonal Projection :—**

This paper is divided into three parts.

In the first part, the number of conditions necessary and sufficient for any plane figure F_1 to be superposable on the projection of another plane figure F are determined.

In the second part, the relations between the elements of a triangle and its projection are discussed and many trigonometrical formulæ deduced.

The third part deals with a number of cases of projection among which may be specially mentioned the projection of a triangle into one similar to itself. Two classes of such triangles are noticed.

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1. Dougall : Loc. Cit.

12. A. A. KRISHNASWAMI AIYANGAR, M.A., L. T.: **Euclidean Constructions :—**

It is the object of this paper to show that instrumental limitations do not really stand in the way of Euclidean constructions. The properties of homothetic figures are utilised to reduce unwieldy configurations to instrumental limits, to find the necessary geometrical elements in the reduced figure taking a suitable centre of similitude, and thence to find the required elements corresponding to those in the latter figure.

13. GOPAL SINGH CHOWLA : **Complex Roots of Equations.**

14. S. V. RAMAMURTHY, M.A., I.C.S. : **Space inside Atom :—**

Bohr depicts the inside of an atom as a discontinuous space with a series of rings of radii varying as the squares of the natural numbers. This space can be transformed into a continuous space by the transformation $r_2 = r^2$. The meaning of this transformed space is furnished by the relation between time and space, viz., $t = r^2$ as obtained in my paper on "*Time, Space, Matter and Mind*" (J.I.M.S., Vol. XV, Nos. 1 and 2). Hence it is shown that space inside the atom is 2 and not 3-dimensional. It is also seen how 3-dimensional space is bound by two 4-dimensional spaces. There is no motion inside the atom. The apparent 3-dimensional space and motion inside the atom are due to vision through our 3-dimensional spectacles.

15. M. BHIMASENA RAO AND M. VENKATARAMA IYER, M A., L.T. : **Evaluation of Persymmetrics :—**

In this paper, the values of two typical persymmetric determinants are found. The elements occurring in the determinants are the 'A' numbers defined in the paper on '*Determinants involving specified numbers*"—(J. I. M. S., Vol. XIV, No. 4.)

Part I :—In this part, a method is given for their evaluation which makes their value to depend on the α's and the q's defined in the same paper.

Part II :—In this part, a different method is given for the evaluation of the same two typical determinants. This method is easier than the former for purposes of direct calculation in particular cases, as when the A's reduce to multiples of co-efficients in Bessel's functions, etc.

Sunday (4th April 1926), 8 A.M.

16. V. RAMASWAMY AIYAR, M.A.: **The Lemoine Points of a Tetrahedron and of Harmonic Polyhedra.**

17. Dr. R. VAIDYANATHASWAMY, M.A., F.R.S.E.: **A Postscript to Poncelet's Theorem**:—

Poncelet's Theorem in its usual form is shewn to depend on two factors; namely, the symmetry and the resolubility of the x-eliminant of two doubly quadratic polynomials in the pairs of variables (x, y), (x, z). It is shewn that there exists (other than Poncelet's Theorem), another case in which the eliminant is resoluble, only one of its factors being, however, symmetric. This leads, when geometrically interpreted, to a new type of closure theorem.

18. A. NARASINGA RAO, M.A.: **Complexes defined by a Collineation**:—

Any non-singular collineation C in S_n determines a complex of lines which may be defined in any of the following ways:—

(i) The totality of lines joining corresponding points of C.

(ii) The totality of lines which meet their corresponding lines in C.

(iii) The totality of lines which are the intersections of corresponding planes in the collineation.

Complexes of S_r's (r-flats) are defined in the same manner and their leading properties derived. The complexes discussed are the analogues in hyperspace of the tetrahedral complex in space of three dimensions.

19. S. PURUSHOTHAM, M.A.: **Conformal Representation in which the Correspondence is (1—2).**

20. K B. MADHAVA, M.A., F.R.A.S. A I.A.: **Socio-Metrical Studies**:–

(*a*) The Incomplete Normal Function.

(*b*) Gamic and Genesic Surfaces.

21. HANS R. GUPTA, B.A.: **The Perpetual Calender Formula.**

22. C. N. SRINIVASA AIYANGAR, M.Sc.: **Theory of Envelopes of Plane Curves.**

23. B. B. BAGI, B.A. : **The General Equation of the Second Degree.**

24. V. THIRUVENKATACHARYA, M.A., L.T. : **Note on Some Infinite Integrals.**

25. A. A. KRISHNASWAMY IYENGAR, M.A., L.T. : **Hindu-Arabic Numerals :—**

1. In this paper the author examines in detail all the available evidence for and against the Arabic as well as the Hindu origin of the modern arithmetical notation and comes to the conclusion that the probability is in favour of Hindu than of Arabic origin. It is shown that the different strata observable in the growth of the notation in the various other countries of the world have their peculiar counterparts in India.

2. One noteworthy feature of development of the numeral notation in India is its progressive continuity and growth—one system leading on to the next and getting itself absorbed in it. There is nothing like it in the notations of other nations; for example, there is hardly any point in common between the earlier Attic notation and the later Greek alphabetic notation.

26. A. A. KRISHNASWAMY IYENGAR, M.A., L.T. : **Circles associated with the Tricusped Hypocycloid :—**

This paper is a sequel to the author's paper on 'The Tricusped Hypocycloid' read before the 13th Session of the Indian Science Congress in January 1926. A number of interesting properties of the tricusp are here deduced by purely geometrical methods from a simple theorem which is believed to be new, *viz.*

The locus of the circum-centre of the triangle formed by any two fixed tangents to a tricusp and a variable tangent is a circle equal in area to the in-circle of the tricusp.

Thus we have—

1. Any four tangents to a tricusp form four triangles whose circum-centres lie upon a circle of the same radius as the in-circle of the tricusp.

This circle is called an associated circle of the first order with respect to the four tangents.

2. Any five tangents to a tricusp being taken, the centres of the five associated circles of the first order which they determine lie on a circle of the same radius called an associated circle of the second order.

Similarly we get associated circles of the third order, fourth order, and so on by taking six tangents, seven tangents, etc.

27. S. L. MALURKAR, B.Sc. : **Pseudo-Foci of Sphero-conics :—**

Two points (pseudo-foci) are found on the axis of a sphero-conic which have properties analogous to the foci. The mutual circle of two conics having the same pseudo-foci is defined. Particular cases are the auxiliary circle and the director circle.

28. S. L. MALURKAR, B. Sc. : **Transformation of Laplace's Equation:–**

For the equation whose solution is symmetrical about an axis, instead of taking as new variables the roots of the equation

$$\frac{x^2}{a^2 + \theta} + \frac{y^2}{b^2 + \theta} = 1,$$

the sum and difference of the distances from the two points $[\pm\sqrt{(a^2 - b^2)}, 0]$ are taken. The solution for a spheroid is given; and incidentally that for an elliptic cylinder.

29. V. RAMASWAMI AIYAR AND M. BHIMASENA RAO :
Miquel Points and Circles :—

The existence of Miquel Points and Circles associated with n co-planar straight lines of which no two are parallel and no three are concurrent, is proved by a method which the authors believe to be new. The equations of the Miquel circles are obtained in the form of determinants, and the Miquel points are exhibited as matrices. The same method is employed to show that, given n lines, the n centre-circles associated with sets of $(n - 1)$ lines are concurrent, and that their centres are situated on a circle which is known as the "Centre-circle" of the given lines.

30. B. S. MADHAVA RAO, M. Sc. : **On the Equi-anharmonic Cubic.**

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Public Lecture on "Philosophy, Mathematics and Science"

BY S. V. RAMAMURTY, I.C.S.

(*2nd April* 1926)

Allow me to thank the organizers of the Indian Mathematical Conference for the honour they have done me in asking me to address you this evening. When I was requested to choose a quasi-mathematical subject to suit an audience of non-mathematicians assembled as the guests of mathematicians, it seemed to me to be a fitting subject to deal with the relations of mathematics with its neighbours—philosophy on the one hand and science on the other. A marked feature of this age which is a cause both of its strength and its weakness and which is perhaps a result of the European genius is its specialization. Life tends to be lived in compartments. One man studies caterpillars and another elliptic functions. One man spends a life-time making a screw and another packs all his religion into Sundays. Religion and business, utility and beauty are all kept apart. The result is that God whom we in India have believed in as the whole of the Universe gets more and more split into differentials. Each of us tends to be attached to a little differential and the integral of all of us is lost to us at infinity. In an excess of veneration for their own achievements, men have come to believe that knowledge is so complex that it is not possible for one man to know more than a little part well. Yet is not the world around us very much more complex than the knowledge that the human mind has spun in its little period of a few thousand years? The complexity of a forest where an innocent deer finds itself at home, the complexity of the solar system where a dead piece of matter roams with an ideally democratic equality with all else that is there—these, to take but two instances, are more complex than the mass of human knowledge. It is a pessimistic view that man cannot take a whole view of knowledge so far won.

It seems to me that there is at the present day a great need to emphasize the importance of a comprehensive knowledge. The most

comprehensive idea that men have evolved is God. According to the Indian view summed up at its best in the Vedantic dictum "Atman is Brahman"—all things, all thoughts, all appearances are but God Himself. It is He that plays as the sea, as men and as stars. It is He that appears as the various systems of Philosophy, the various branches of Mathematics, the various wonders of Science. It is He that dances, that blazes with colour, that weeps, that dies. When we can conceive of God, can we not conceive of the common basis of knowledge, be it philosophy, mathematics or science? I would go further and say that the more discrete knowledge becomes, the further you move from the conception of God.

There is an interesting story in the Taithiriyaka-Upanishad which tells how Bhrigu found an increasingly comprehensive series of ideas which approximated to Brahman. His father Varuna defined Brahman to him thus: "That from whence these beings are born, that by which, when born, they live, that into which they enter at their death." Bhrigu performed *tapas* and thought that Brahman was *anna*, matter. Varuna said "Think again" Bhrigu again performed *tapas* and found *prana*, life, was Brahman. Varuna said "Think again." Bhrigu again performed *tapas* and found *manas*, mind, was Brahman. Varuna said "Think again." And so on, Bhrigu passed through *vignana*, understanding, *ananda*, bliss. In the Brihadaranyaka Upanishad, *akasa*, space, is similarly introduced. Fundamental ideas and comprehensive ideas are much the same. The former are seen at the depths and the latter at the heights.

In pre-Leibnitzian European philosophy, the Universe was considered as made of matter residing in an absolute space and an absolute time with God superintending the whole. This view started originally in Greece. The mathematical theories of continuity and infinity depend on the conceptions of absolute space and absolute time. Newtonian mechanics which accepts this Trinity of Time, Space and Matter has been the foundation of European science.

Combining the Upanishadic view with that of modern science, I take Time, Space, Matter and Mind as four fundamental entities, *prana* and *manas* I put as Mind.

Next to *manas*, we are aware of some entity beyond, which we call Spirit,—either the spirit within our individual self called *Jivatma*, or the spirit of the cosmos called the *Paramatma* or God. *Vignana* and *Ananda* I combine under Spirit. And as at the source of all things in the Universe, as at the final boundary of God, and as penetrating right through all is Brahman. I would therefore re-arrange the series of fundamental entities as Brahman, Time, Space, Matter, Mind, Spirit, Brahman.

If these are fundamental entities, how then are we to recognize the oneness of the Universe? An attempt in this direction has been made by the Einstenian theory. Time and Space are not according to Einstein absolute and independent. There is an entity called Space-Time of which time is a one-dimensional section and space a three-dimensional section. In such a world matter is considered a kind of kink. As the nature of this kink is not explained in terms of Space-Time, it still continues in nature as isolated as before. Next there is the category of mind in the world. If the world is a four-dimensional Space-Time, what is the relation of Mind to it? Einstein is himself entirely unconcerned with the relation of mind to the physical universe which he regards as four-dimensional Space-Time. It is idealist philosophers like Wildon Carr that are attempting to draw out the implications of Relativity Theory in regard to mind. So far as Einstein is concerned, the only part of the observer that comes into his theory is his motion—uniform or otherwise. Next in the extension of this theory to Electricity, the size of the observer has also become relevant as it furnishes him his gauge system. Thus the observer need only possess motion and size for the purpose of the Einstenians. Wildon Carr however identifies the observer of Einstein with the monad of Leibnitz. Leibnitz considers the world as made up of a number of monads which may be regarded as atoms of mind. All these monads have according to him a pre-ordained harmony. The general principle of Relativity is on the view of Wildon Carr an expression of the pre-ordained harmony of Leibnitz. Einstein however entirely fights shy of mind and philosophy. He thinks of no monads and of no harmony between them. He in fact takes no view of the outside world but deduces the observed facts of the outside world as the result of the system of axes which man himself sets up. The form of measurements according to him is the

result not of the thing measured but of the measurer himself—being the result of his motion and his size.

The fact seems to me to be that there is confusion between the provider of the new view and its interpreters. While Einstein ignores philosophy, Wildon Carr claims that Relativity has converted science into philosophy. I told Professor Weyl at Zurich that the cause of confusion is due to mistaking mind for time. It is not, I said, the addition of time which raises space into a four-dimensional entity. We cannot imagine the world going astray in time or becoming timeless when men vanish. What is introduced by Einstein is an observer though only the relevance of parts of him is yet recognized The addition to the world is therefore not time but mind. It is not Space-Time, but Space-Mind that is four-dimensional.

The problem of the reconciliation of the series of fundamental entities with the one entity of God is the age-old problem on which Asia and Europe are divided. Asia starts with God. Europe works towards Him. In their ideals, their ways of thought, their methods of action, Asiatics believe in the existence of the One amid the variety of the world. It is not the appearance of variety that is real to us but the existence of the One. We seek to draw out the melody of God in life. Europe seeks to build the harmony of the world towards Godhead.

It seems to me to be possible to recognize the oneness of the apparently fundamental entities. I regard the latter neither as absolute nor as relative but as relatively absolute. I have been seeking to establish a relation between Time, Space, Matter and Mind which accounts both for their difference and their oneness—like rupees and pice which are both different and yet are one. I have laid down a hypothesis that what constitutes the difference between Time, Space, Matter and Mind is a difference in the scale of size of their particles. The atomicity of the particles is not a new idea as we recognize the atomicity of the observer. The size of the particles is relevant in the same way as the size of the observer is relevant in the Einstein theory in drawing out the laws of Electricity. From this arithmetical relation of Time, Space, Matter and Mind, I proceed on a theory of dimensions to deduce a geometrical relation between time, space, matter and mind. I

regard time as the first manifestation of the undifferentiated Brahman. The primal mystery of the Universe is the evolution of the unit. When one unit of time, that is the smallest atom of Brahman we can recognize in perception or conception evolves, the whole of the Universe can then be constructed. When one unit of time is evolved, the addition of other units gives us numbers.

There is only one mathematical definition of numbers now extant—that of Bertrand Russell as a class of similar classes I have analyzed his definition and have tried to show that an integral number may be defined more simply as a piece of time. As an infinite number of atoms of time is gathered, the group changes in quality as he who has a million is different in quality from him who has a few rupees though both have wealth. I start with the infinite group of time atoms as an atom of space and build an atom of matter with an infinite group of space particles. And so again with mind. The infinite number of particles required to change quality is dependent on our notion of size and therefore on our size. The recognition of the smallest atom is also dependent on our own size which gives us the smallest size we can recognize. The evolution of quality is based on quantity. Quantity itself is born with the first emanation of quality. Descartes has said : " Give me matter and motion and I shall construct the universe." Eddington has said that as matter is recognized to be motion, it is enough to say : " Give me motion and I shall construct the universe." It seems to me we can go further and say : " Give me a point and I shall construct the universe." Points, as I had occasion to state to the session of the Mathematical Conference at Lahore, are of various kinds—Time, Space, Matter, Mind and I may add Spirit. Give me a point of time, we can build up the universe. Let me give an instance of my dictum where you can recognize its truth. Take the point which is an atom of mind in the shape of man When man is born, you have a whole universe constructed with him. It is true to say then " Given a point of mind, a whole universe can be constructed."

So then in substance, the world in spite of differentiation into relatively absolute divisions is but one. What is the relation of philosophy, science and mathematics to this division ?

Philosophy deals with the entity mind—the difference between different systems of philosophy does not lie in that one deals with

mind and another does not; but rather it consists in one emphasizing the relation of mind to the world of matter outside and another the relation of mind to the world of spirit within. We can imagine the world moving as it does if all mind is withdrawn from it—the cognizing mind being a small particle of mind to know what is going on without affecting it—just as we introduce a test particle of electricity to test a field without affecting it. But it is obviously not possible to imagine goodness, truth and beauty to reside in the world if mind is withdrawn. Philosophy deals with mind either by itself or as emanating from matter or as leading to spirit.

Science on the other hand deals with matter. Physics and Chemistry deal with it obviously. Biology deals with the material bodies and material characteristics of life. Psychology is on the borderland of science and philosophy and partakes of the character of both.

Along with the difference in the substance of which they treat, there are differences in their methods. It is usual to say that where philosophy uses deduction, science uses induction. Philosophy starts with truths from which it seeks to draw useful deductions, while science gathers up facts of experience and seeks to draw their common truth. In so far as the purpose of science or philosophy is to live a good life while mind is enclosed in a material body, the difference I have referred to is natural. Science deals with matter. If it is sought to be useful to mind, the facts of matter have to be gathered and built up into mind. This is the inductive process. If philosophy is sought to be used in living a material life, the truths of mind have to be broken up into material results. This gives the deductive process. But it is at the same time a mistake to regard philosophy as concerned only with deduction. For mind is in relation not only to matter but also to spirit. Even as we build up from matter to mind so too we build up from mind to spirit. Religion which deals with spirit is therefore the result of an induction from philosophy as philosophy is from science. So too from religion, by a process of deduction, we arrive at philosophy and then science.

What form does the inductive method take when used by philosophy? This is what has been called *tapas* in India. Even

as scientists throw together pieces of matter in a crucible and try to achieve their summation, so too a philosopher throws together ideas in the laboratory of his mind, boils them with constant meditation and builds up new ideas as their summation. The ancient Rishis of India were not men who sat lazily in intellectual torpor pretending to look at the tips of their noses. They were men aglow with intellectual curiosity, persistent energy and a sense of adventure. The reality which appealed to them was the world of spirit and not the world of matter. They were therefore employing the method of induction even as scientists do to get the truths that are embodied in material events. The modern counterparts of the ancient Rishis are the Dons of a University like Cambridge or Oxford—men who give up the ordinary life and devote themselves to the pursuit of truth. It is a mistake to suppose that truth can be tested only in a material laboratory and not in the laboratory of the mind. The former is easier to communicate to others than the latter is. But the validity of truth to the seeker is on an equal footing in each. Laws of nature are relations between matter, space and time perceived by mind. They are relations between mind on the one hand and the world of matter on the other. In arriving at such laws, it is wrong to insist on their satisfying material and not intellectual tests.

Where then does Mathematics stand in relation to Philosophy and Science, or in relation to the series of fundamental entities that I have listed? It surely does not deal with matter alone or with mind alone or with space alone. It deals with the relation of mind to matter, of matter to space or time, of space to time, and so forth. It deals thus with the connections between the various entities, or as I have put it on a previous occasion, Mathematics provides bridges between the various entities in the series that I have given. Geometry deals with the special properties of Time. It is the bridge between Time and Space. Newtonian mechanics deals with the material properties of Space. It is the bridge between Matter and Space. The next great bridge which has to be constructed is that between Matter and Life and this will yield us four-dimensional mathematics. And is there not a bridge between Brahman and Time? The system of numbers deals with the Time properties of Brahman, with the concrete properties of the abstract.

And there is one bridge which is at the back of all, the very model of all the bridges that ever have been and ever shall be, and that is the Upanishadic formula that Atman is Brahman whether Atman be Time or Space or Matter or Mind or God Himself. That formula is the summit of mathematical truth.

Mathematics may be defined as the mechanism whereby the orderliness of that which is within us cognizes the orderliness of that which is without us. Standing at the junction of Brahman and Time, time is within the self and is subjective. With the inner time-consciousness we study Brahman and produce Numbers. I use consciousness to mean subjective vision. Standing at the junction of Space and Time, space is within the self and is subjective. With the inner space-consciousness we study Time and produce Geometry. Standing at the junction of Matter and Space, matter is subjective and we study space with the consciousness of matter. The result is Mechanics. We have now reached the junction of Matter and Mind. With the consciousness of mind, we have to study matter. The failure of Einstein has been so far due to the combination of his enhanced consciousness with his old methods of activity. He indeed continues to study matter with the measuring rods of dead matter and not with new measuring rods of mind which is his self. Hence the elaborate crudity of Einsteinian mechanics.

The fact now is that we have mistaken our body to be our self. The texture of our perceptions is material. Logic has been mistakenly viewed as absolute. It is not so. Logic and Geometry are the obverses of each other. The texture of the world without and the world within are reflections of each other. We take it as a principle of Logic that A cannot be both B and not-B. This is the same truth as that you cannot walk both forwards and backwards, or that you cannot be both in Madras and in Bangalore. But when Geometry attains an enhanced structure, there is no reason why Logic should not do so too. Just as men have studied *n*-dimensional Geometry as a theoretic piece of work long before Einstein propounded the actual world to be four-dimensional, so also Indian logicians have evolved a system of logic which takes in the category of that which both is and is not and thereby denies the law of the exclusion of the middle. But as may be naturally expected in

India, this category does not spring up purely as a theory but is needed to cognize Brahman which both is and is not, to cognize God who is described in the Puranas as a synthesis of contradictories, as, for instance, greater than the greatest and smaller than the smallest. It is to be expected that this category may be brought down by a process of deduction to the world we live in. I believe in fact that it can be. I believe that in a four-dimensional world which is viewed with a harmonizing vision, straight lines have three directions—one positive, one negative and one both positive and negative. Einstein changes his Geometry and does not change his Logic. Hencehis theory is as troublesome as new wine in an old bottle.

It is a mistaken view of the nature of Reality that makes Einsteinians assert that the world is only four-dimensional. The dimensions of the world depend on the observer, or to put it in another way, on the observed. By the world we mean what is outside us and not that which is within us. That which is within and that which is without together make up the Universe for us. If the world outside is matter, the outside world is three-dimensional. If the world outside is mind, the outside world is four-dimensional. It may be objected that the world where the Perihelion of Mercury is manifested is a world of matter only. I would suggest with all respect that it is not correct. As I believe that mind and matter differ by having atoms of different scales of size, so too when we reach large lengths like Planetary distances, we probably reach a region of mind. And perhaps to a body of Hindus I may not be far wrong even in this Europeanized and de-Indianized age to say that our forefathers in attributing mind to the Sun and the Planets had perhaps grounds for doing so. There are many mounds in Indian History and thought which look as useless outwardly as the mounds at Mahinjo Daro or Harappa. But dig under, dig deep and great facts, great truths come to light.

My walking stick has size and motion. It is enough to constitute an Einsteinian observer. But surely the stick is but an index of myself. In building up the world of the walking stick plus what is perceived at it, surely Einstein leaves out much of the Reality. All that can be said is that a four-dimensional world comprehends more of the Universe than a three-dimensional world

because it contains mind in addition to matter. But if we study only the world without mind, it is certainly correct to say it is three-dimensional. If we can throw out into the objective world even more than mind, it will become a more comprehensive world still. Hence the most complete view of the world is not that it is three-dimensional matter or four-dimensional mind but that it is God Himself, for God, be He within or be He without, is the largest idea we have arrived at. And God Himself is a relative being. It is said that God created man. It is equally true to say that man will create God. There seems to be a direction for world development. Betrand Russell says in his "*A. B. C. of Atoms*:"—"Perhaps the Universe has long cycles of alternate winding-up and running down; if so, we are in the part of the cycle in which the Universe (or at least our portion of it) runs down." The creation of man by God is the winding-up process. The creation of God by man is the running down process. We prefer to restrict the term "creation" to the former process; but if cause is to precede effect, it is equally true that it is man that is creating God and perhaps God Himself will come out greater from the process of re-creation by His own children.

Thus, Reality is not absolute—not even the reality of God. It is therefore possible to study a two-dimensional Reality—which is I believe the reality inside an atom. We have been familiarized in recent years with the wonderful planetary system inside an atom—how it has a central proton and several electrons spinning round it. But Bohr postulates that it is a very curious kind of space inside the atom. The various orbits have nothing between. An electron either moves in its own orbit or jumps into the next in no time and through no space. This looks very much like a traveller's tale. The traveller who goes to a new country has to compare his own pre-conceived ideas with what he finds in the new country. He regroups the ideas of the new country into forms familiar to himself and rejects the rest as chaos, as things that may as well not exist. With our material three-dimensional modes of vision and of thought, when we peer inside an atom, we recognize what is familiar. We drop the rest and we magnify the whole into a semblance of our material world. I believe that it is a myth of science that space inside the atom is three-dimensional. Motion

is attached to matter. When there is no matter, there is no mechanics. Inside the atom which is a region of electricity, I believe we have a two-dimensional flat land where things but stay and do not move. It is as important to study two-dimensional space as it is to study four-dimensional space. The mysteries of electricity and of the quantum are, I believe, involved in the study of the two-dimensional continuum.

Thus the Reality can be studied either objectively or subjectively—either through experiment or through meditation. We may identify ourselves in thought with a God or an atom of space and proceed with intensive experimenting inside consciousness. Both methods are necessary for the advance of truth. The importance of experiment need not be emphasized at this time. But let me emphasize the importance of meditation as a mathematical method. Meditation walks where intuition runs and a Ramanujan gallops. It is a process of building up, of creation. It is a method which has been developed in India through many centuries. How did the Seers of the Upanishads arrive at their series of comprehensive ideas? It was by meditation.

Professor Eddington in his "*Space, Time and Gravitation*" points out that probably the only law of nature which seems to be independent of the observer is the law of atomicity. As I have said before, even atomicity of the world is a reflexion of man's own atomicity. So we may agree, to an even greater extent than Eddington himself thought of, with the last words of his book :— "We have found a strange foot-print on the shores of the unknown. We have devised profound theories one after another to account for its origin. At last, we have succeeded in reconstructing the creature that made the foot print. And Lo! it is our own-Self."

And this is just what we should expect. The nature of the observed world is the complement of the nature of the observer. Hence it is we can deduce the laws of nature from axes of our own manufacture.

To sum up then, the Universe is made up of several relatively absolute entities which are different and yet are one. Each entity gives rise to a branch of knowledge—spirit gives Religion, mind gives Philosophy, matter gives Science. The relations of two or more entities give Mathematics. To study these entities and watch their mutual relations makes life indeed a glorious adventure.

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33. Mr. K. C. Shah, Sind.

34. ,, G. A. Srinivasan, M.A., L.T.,
Prof. of Maths., Maharaja's College, Ernakulam.

35. Mr. C. N. Srinivasa Iyengar, M.Sc., Central College, Bangalore.

36. „ K. R. Srinivasa Iyengar, M.A., First Member of Council, Bangalore.

37. „ K. Srinivasaraghavan, Kumbakonam.

38. „ L. N. Subramanian, M.A., L.T., Asst. Prof. of Maths., Christian College, Madras.

39. „ V. Thiruvenkatacharya, M.A., L.T., Asst. Lecturer, Govt. College, Palghat.

40. „ T. P. Trivedi, M.A., LL.B., Prof. of Maths., Bhavnagar.

41. „ M. Vaidyanathan, M.A., L.T., Pachaiyappa's College, Madras.

42. Dr. R. Vaidyanathaswami, M.A., F.R.S.E., D.Sc., 84, Big Street, Triplicane, Madras.

President's Concluding Speech.

GENTLEMEN,

Before bringing the Proceedings of the Conference to a close, I should like to offer a few concluding remarks. You all know that for these three days we have been meeting and having papers read or discussions held. I shall be failing in my duty if I do not express my sincere appreciation of the love of those who have come from far off Lahore, Ajmere, Nagpur, Karachi, Sind, &c., to attend the Conference and those who have enlightened us with their papers. As a senior member I take the liberty of saying that it is not enough if we disperse now and sleep over the whole thing as soon as we get back to our homes. As pointed out in my Presidential Address, each one of us must feel wedded to the subject of Mathematics and try to contribute our mite towards the promotion of Study and Research in our country.

Here we have all met as brethren interested in the subject and if we can form ourselves into groups for the purpose of studying different branches of the subject before we disperse, and if the members of each group will keep themselves in touch with one another by correspondence afterwards and come up to the last of the stages in the "mile," we shall have done something and the Conference will have achieved its object.

After eighteen years of existence our Society has attained majority as we have said: still, looking back we cannot feel that the work that has been done has been any way very satisfactory. Our journal as I pointed out, is still not up to the mark in that it contains both elementary and advanced matter all mixed together and the Editor has had often to complain that he has not got enough matter forthcoming for the different parts. I shall take this opportunity of appealing to you to get this defect removed early so that our journal is developed into one that can stand compari[illegible] with the leading Mathematical Journals abroad. Also every [illegible]

us must see that our Society is made better known and each try to enlist one additional member at least.

Before I conclude, it is my pleasing duty to convey on behalf of the Society our heartfelt thanks to His Highness the Mararaja for the gracious Message of Welcome and to the Mysore University for its munificent donation and other facilities given. We are specially thankful to the Vice-Chancellor Rajatantrapravina Dr. Brajendranath Seal, M.A., Ph.D., D.Sc., for the great interest he has taken in the Conference and the lead he gave to the Proceedings in his Opening Speech. Our thanks are also due to Dr. E. P. Metcalfe, D.Sc., Principal, Central College, for placing the Central College and its Hostel at our disposal; and to the Principal of the College of Engineering for the interesting programme he had arranged on the occasion of our visit to the College. We are under deep obligations to Dr. M. O Forster, the Director of the Indian Institute of Science, to Mr. Y. Narasinga Rao, Director, Sandal Oil Factory, and to the officers in charge of the Jewell Filters and the B. P. L. " A " Station for the kind and instructive way in which they showed us round their respective institutions. We are grateful that the Reception Committee has made the arrangements so well as to make us feel no want whatever—special mention has to be made of the attention bestowed on us by Mr. S. A. Ramaswami Iyer, Dr. M. A. Sampathkumaran, Mr. V. Gopalaswamiengar, and their co-workers and the Volunteers.

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